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Carbon capture and storage business models

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Abstract

Sound, viable business models will be needed if deployment of CCS as a GHG mitigation option is to be widespread. The large opportunity for CCS to mitigate CO_2 emissions has focused attention towards potential business models, enabling technologies, and regulatory frameworks. Drawing on examples from participants in a roundtable of the industries involved -- organized by IPIECA in June 2007 -- the realities that challenge CCS business models and potential solutions to these challenges are explored.

Keywords: *CCS; business models; greenhouse gas; climate; CO2; carbon*

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1. Introduction to CCS business models

Simply put, a business model defines what problem the business solves and how it does so profitably. Businesses involved in making CCS a reality would include both those businesses involved in the components of the CCS chain (capture, transport, injection and storage), supply chains for those businesses, and more – a network of partners. At this stage policy drivers and economics bases are generally not yet sufficient to overcome the added costs of CCS and animate business models. Therefore, there is currently no established CCS business model.

For CCS, profitability will depend on the policy and regulatory context – the business environment – and, conversely, the policy and regulatory context may be shaped by the prospective solutions that business models may provide to the range of challenges faced by a CCS business.

To develop understanding within, and between industry sectors, on key issues surrounding CCS business model development IPIECA held a cross-industry event in Oslo in June 2007. It brought together experts from petroleum, coal, and power, and service & equipment providers and government representatives to address:

- Partners and roles in the CCS value chain
- Contracting and agreements
- Policies to create a value proposition
- Legal and regulatory framework to enable business models

Material from that workshop is available from IPIECA [1]. Extending from discussions begun at that event, this paper explores the challenges faced by CCS business models and the ways in which prospective business models are adjusting to meet these challenges

2. Realities faced by CCS business models

Business models being considered by industries reveal a range of realities, and ways business models are adapted to these realities. Realities include:

- relevant technological understanding lies mostly in the oil and gas sector, with the principle opportunity for CO_2 capture lying in the power sector – see Figure 1
- lack of certainty surrounding technological improvement, policy drivers, legal and regulatory framework, and especially public acceptance and support
- lack of process integration experience for capture schemes using existing technologies
- differing concepts of governments' roles in the CCS value chain: capture, transport, injection, storage
- significant initial capital and time required for infrastructure development
- opportunities and limitations for matching CO_2 supply and storage (especially for EOR)
- common interest in development of a potentially huge CCS endeavor

Prerequisites for CCS business models, from a utility perspective, were highlighted by Heithoff [2] along with some potential implications. First, the core competencies reside in different existing businesses for the elements of the CCS process chain as applies to power generation – power, capture, transport, and storage – pointing to partnerships between businesses with competencies in these areas. Second, contractual agreements would be needed describing the obligations of partners, and raise the prospect that CCS would be a heavily regulated business under state supervision. Third, is the obvious gap preventing CCS from being currently economic, given no existing CCS market, raising the question of how to produce a level playing field for business and the prospect of targeted incentives and their effect on CCS business models. Finally, the legal framework is generally non-existent but it is under development in some areas. The development of regulations, laws and liability will influence the pace and business environment for business models. Drawing on existing frameworks -- such as those in place in the oil and gas, and mining industries – may reduce the uncertainty relative to an entirely new framework and draw on existing institutions and legal capacity.

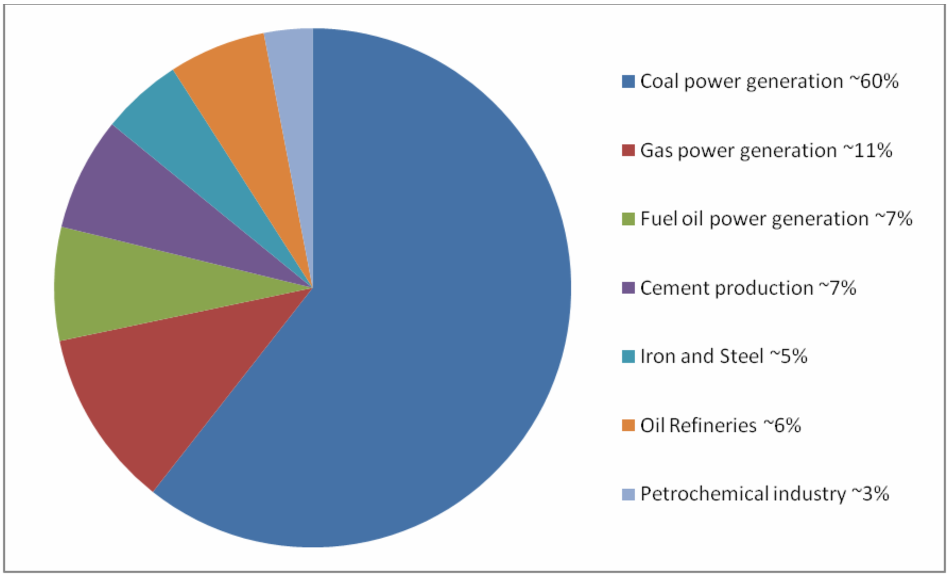

Figure 1. Fraction of large stationary sources of CO_2 (larger than 100 kt CO_2/yr) associated with industrial sectors. Based on data from IPCC [3].

3. CCS Process, Supply, and Value Chains

The CCS process chain of capture, transport and storage (see Figure 2) adds to the processes such as power production that provide energy or other industrial services. As mentioned above, different industries have competency in different parts of the process chain. Recognizing that CCS economics relies on economy-of-scale, industrial capacity to provide widespread deployment would need to respond effectively to a large number of multi-billion dollar investment decisions.

The manufacture of an overall process relies in its supply chains for materials and equipment. For example, Stobbs [4] described the design of a SaskPower oxyfuel process for the capture of CO_2 in coal-fired power generation where major pieces of process equipment are designed by a number of suppliers (Hitachi, Marubeni, Alstrom, Air Liquide, and B&W). Projects will rely on the successful operation and performance of supply chains.

The cost of capture generally expected to dominate the total cost of CCS for power applications implying that significant capacity to develop and manufacture capture equipment would be needed if CCS were broadly deployed. Investment could lead to such capacity, however, it remains unclear which capture technologies will ultimately succeed complicating such an investment decision.

The full scale deployment of CCS would entail significant investment over decades for an infrastructure of pipelines to transport CO2 from capture facilities to storage sites. This would be of comparable scale to that of the global oil and gas industry, if CCS deployment is to provide one of several technology paths that are modeled [3] to have a substantial impact on greenhouse gas emissions. Building this infrastructure would also draw on resources such as steel that are currently under high demand to meet other pressing needs.

Infrastructure can serve a network of projects, entail significant up-front cost, and take time to acquire right-of-way, permit and ultimately build and operate making decisions and planning of pipeline networks a significant endeavor. Pipeline networks could grow from small but existing networks – like those used for enhanced oil recovery [5] – or a new network could be created. For example, Robson [6] described the Integrated CO_2 Network -- ICO_2N -- a large planned open-access CO_2 pipeline network connecting multiple capture and storage locations in Alberta, intended to optimize long-term efficiency for multiple industry sectors, and with coordinated input from

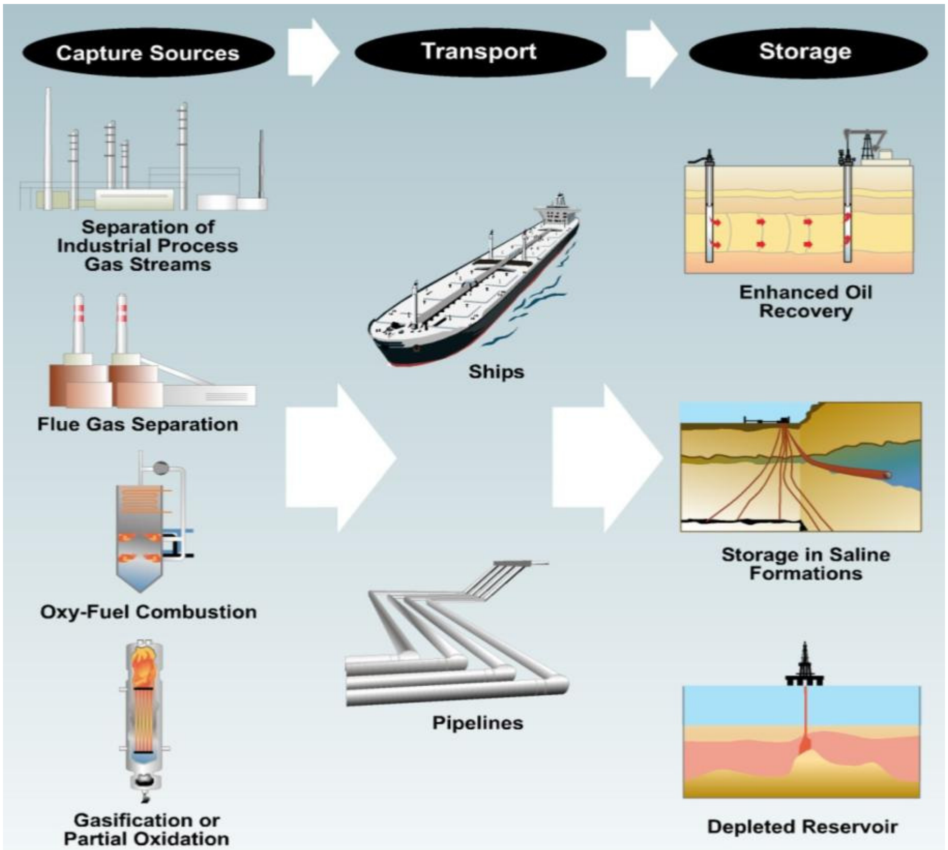

Figure 2. The CCS process chain. Adapted from IEA [11].

government. ICO_2N partners include: Suncore, TransAlta, Agrium, ConocoPhilips, Nexen, Husky Energy, Sherritt International, Syncrude, Shell Canada, Air Products, CNRL, Imperial Oil, EPCOR, and Keyera.

To animate business models for CCS, not only would an overall value proposition be necessary, that value proposition would need to span the process and supply chains making up the value chain. To day these conditions are not sufficient to drive widespread deployment. McLemore [7] described these current deficiencies in the value chain: To reach breakeven economics, he estimated the CO_2 value required for the entire value chain is between $30 and $110/t CO_2 depending on technologies needed and scale involved. Uncertainty associated with regulatory environment and long term value of CO_2 implies high uncertainty associated with CCS opportunities. Given the higher oil price ranges, EOR projects have positive net present value potential over large ranges of uncertainties although their opportunities are limited and they are currently often limited by CO_2 supply. For non-EOR projects to be attractive (with current technology) the anti cipated value chain requires long term CO2 prices to be significantly above current levels. And existing CO_2 pipeline infrastructure is minimal: substantial investment is needed for a complete C CS chain and pipeline permitting and rights of way will be ch allenging.

4. Ownership and liability

Multiple uses of geologic formations raise complexity of ownership and liability issues. The prospective areas in sedimentary basins where saline formations, oil or gas fields, or coal beds suitable for storage may be found – as illustrated by the IPCC [3] – have significant overlap with areas of current or potential fossil fuel production. There is an emerging need for the co-existence of oil and gas, and CCS activities.

Bradshaw [8] outlined efforts to design the legal and regulatory frameworks needed to address ownership and liability issues in the Australian context. A legal and regulatory framework is progressing in Australia [9-10] to clarify the rights and liabilities of owners and produce a workable approach to long term stewardship of storage sites. While each nation or region may develop their own framework for ownership and liability issues, there may well be sharing of approaches between regions.

As rules develop, we expect that business models will evolve to conform to the rules, but can only exist if the rules provide a space for workable business models and the substantial investments that are involved in CCS projects.

5. Contracting and Agreements

Two challenges for CCS have been and still are: finding an overall value proposition that is economically viable, and forming attractive value sharing arrangements between partners in the value chain. With long-term, large, capital-intensive investments on the order of a billion dollars, there needs to be a clear understanding of the long term basis of the value proposition – e.g. 20 years and beyond – as well as the terms for partners in an agreement.

Contracting and agreements will need to address a number of factors as has been described by McLemore [7]. Partner agreements will likely also be long-term and need to address the uncertainties associated with evolving regulatory environment and CO_2 value. The partners involved can include: CO_2 emitters, capture investment owners and operators, pipeline transportation companies, and storage owners and operators. Partnership considerations include: capital constraints, expected returns on capital, level of experience in technology, risk appetite, and operational standards.

Agreements can accommodate a wide range of considerations, however, the large uncertainties regarding CCS acceptability, and legal and regulatory frameworks add complexity to such agreements, and obviously the general lack of a value proposition limits agreements to special early instances where CCS is applied.

6. CCS Demonstrations

There is now great interest in the demonstration of CCS [12,13]. There is a growing portfolio of demonstrations worldwide with some planned, some cancelled, and some ongoing [14]. There remain no full-scale demonstrations of CCS applied to power generation – the application that has the greatest potential scope. Demonstrations do take time, and considerable resources, to move from planning to completion of their objectives. For example, Mudd's [15] description of a large demonstration timeline spanned over a decade.

Demonstrations will affect CCS business models – providing learning, influencing the business environment, and impacting public acceptance. As interest in carrying out demonstrations builds, better understanding what are their objectives, how their objectives may address the realities of a potential future CCS business, and how CCS business models can enable their timely execution are all near-term priorities for study.

7. Conclusions

At this stage policy drivers and economics bases are generally not yet sufficient to overcome the added costs of CCS and animate business models. Therefore, there is currently no broadly viable business model for large-scale deployment of CCS. Correspondingly, institutions to govern and regulate potential CCS business are not fully developed, and in some regions they are non-existent. As CCS policy, regulatory frameworks, and business models co-evolve, there is a need to better understand the changing relationship between potential business models, existing industries, and government. If CCS is to grow at the pace envisioned in many GHG mitigation scenarios, this evolution will need to progress rapidly and effectively.

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